BEFORE THE
PUBLIC SERVICE COMMISSION OF WISCONSIN

Application of Highland Wind Farm, LLC, for a Certificate of Public Convenience and Necessity To Construct a 102.5 Megawatt Wind Electric Generation Facility and Associated Electric Facilities, to be Located In the Towns of Forest and Cylon, St. Croix County, Wisconsin	Docket No. 2535-CE-100

Ex.-CW-Cook-4

Please enter the attached exhibit, Ex.-CW-Cook-4, *Nocebo responses to high-voltage power lines: Evidence from a prospective field study,* by Porsius, et al. Sci. of Tot.Env. 543 (2016) 432-438, November 2015.

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Nocebo responses to high-voltage power lines: Evidence from a prospective field study

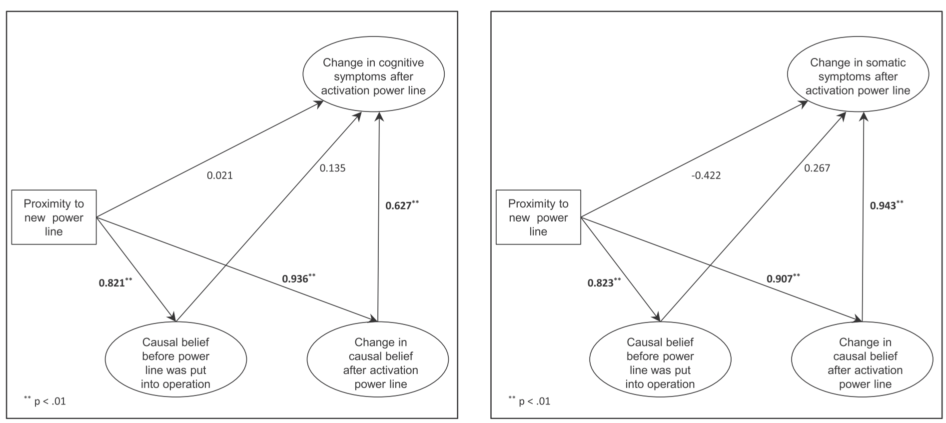
Jarry T. Porsius [a], Liesbeth Claassen [a,b], Fred Woudenberg [c], Tjabe Smid [a,d], Danielle R.M. Timmermans [a,b,*]

[a] Department of Public and Occupational Health, EMGO Institute for Health and Care Research, VU University Medical Center, Amsterdam, The Netherlands
[b] National Institute for Public Health and the Environment, Bilthoven, The Netherlands
[c] Municipal Health Service, Amsterdam, The Netherlands
[d] KLM Health Services, Schiphol, The Netherlands

HIGHLIGHTS

- We studied residents' health responses to the introduction of a new power line.
- Proximity to the power line was associated with higher symptom reports.
- The increase in reported symptoms was explained by health risk perceptions.
- Putting a power line into operation may lead to nocebo responses.

GRAPHICAL ABSTRACT



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ABSTRACT

Background: Experimental studies suggest that nocebo responses might occur after exposure to equipment emitting electromagnetic fields such as high voltage power lines (HVPLs) or mobile phone base stations.
Objectives: The present study investigates to what extent health responses to a new HVPL can be explained by beliefs of residents regarding the health effects of HVPLs.
Methods: We used a quasi-experimental prospective field study design with two pretests during the construction of a new HVPL, and two posttests after it has been put into operation. Residents living near (0–300 m, n = 229; 300–500 m, n = 489) and farther away (500–2000 m, n = 536) filled out questionnaires about their health and their beliefs about the negative health effects of power lines. Longitudinal mediation models were applied to investigate to what extent these beliefs could explain a change in reported symptoms after the new line was put into operation.
Results: Significant ($p < .01$) indirect effects were found for proximity on the increase in reported cognitive ($R^2 = 0.41$) and somatic ($R^2 = 0.79$) symptoms after the power line was put into operation through an increase in the belief that power lines causes health effects. The direct effects of proximity on an increase in reported symptoms were not significant.
Conclusions: Our findings suggest that increases in reported health complaints after a new HVPL has been put into

* Corresponding author at: VU University Medical Center, Department of Public and Occupational Health, P.O. Box 7057, 1007 MB Amsterdam, The Netherlands.
E-mail address: drm.timmermans@vumc.nl (D.R.M. Timmermans).

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operation can be explained by nocebo mechanisms. Future field studies are needed to know whether our findings extend to other environmental health issues in a community.

Keywords:
Nocebo
Power lines
Electromagnetic fields
Symptom reports
Environmental health risk

1. Introduction

In the medical field an increase in symptom reports after exposure to an inert treatment is described as a nocebo response (Barsky et al., 2002; Tracey, 2010). Meta-analyses of clinical trials indicate that these adverse responses to placebo medication are very common (Mitsikostas et al., 2012; Mitsikostas et al., 2014) and that the effects can be strong (Petersen et al., 2014). Laboratory experiments demonstrate that these findings also extend to health responses to environmental exposures. For instance, sham exposure to electromagnetic fields (EMF) (Szemerszky et al., 2010; Witthoft and Rubin, 2013) or sham infrasound from wind turbines (Crichton et al., 2014) led to an increase in reported symptoms. In addition, observational studies suggest that concerns about the effects of environmental exposures on one's own personal health are associated with decreased well-being and increased health care use (Filipkowski et al., 2010; Petrie et al., 2001; Rief et al., 2012). In the present prospective field study we investigate whether an increase in reported symptoms after exposure to a potential environmental health risk can be explained by beliefs about the negative health effects regarding the exposure.

Several biopsychological mechanisms are likely involved in producing nocebo responses (see Benedetti et al., 2007; Stewart-Williams and Podd, 2004; Tracey, 2010). The beliefs that people have about the negative health effects of a treatment or exposure, specifically expectations regarding future negative health outcomes, are considered to play a central role in explaining these nocebo responses (Benedetti, 2014; Bensing and Verheul, 2010; Colloca and Finniss, 2012; Faasse and Petrie, 2013; Hahn, 1997). If one believes that being exposed leads to the experience of health complaints, somatic sensations may be amplified and provoke anxiety which is experienced as physical symptoms caused by the exposure (Lees-Haley and Brown, 1992; MacGregor and Fleming, 1996; Page et al., 2006; Spurgeon, 2002). The role of beliefs regarding environmental exposures in health responses is demonstrated in an experiment where an initial nocebo response elicited by giving negative information about a sham exposure, was reversed to a placebo response by providing counter information about the positive health effects of the exposure (Crichton and Petrie, 2015).

One example of exposure to a potential environmental health risk that could lead to nocebo responses are electromagnetic fields emitted by high-voltage power lines (HVPLs) or mobile phone base stations. A large part of the European population (around 70%) believes that mobile phone base stations and HVPLs affect their health to at least some extent (TNS Opinion and Social, 2010). Interviews with residents living near existing or planned HVPLs, reveal that they associate non-specific health complaints such as tiredness, headaches and neurological problems with exposure to EMF from power lines (Cox et al., 2005; Porsius et al., 2015a). This is in line with other studies showing that between 1.5 to 13.4% of the worldwide population report suffering from "Idiopathic Environmental Intolerance Attributed to EMF" (IEI-EMF, formerly known as electromagnetic hypersensitivity) and attribute non-specific health complaints to exposure from EMF emitted by various electrical sources such as power lines (Baliatsas et al., 2012). This self-diagnosed disease is associated with serious functional impairments and distress (Foster and Rubin, 2014; Kato and Johansson, 2012). There is no plausible biological mechanism known to explain how exposure to EMF under the current exposure norms could lead to non-specific health complaints and most experts consider the health risks as nonexistent or small (Repacholi, 2012; Roosli et al., 2010). Several researchers have suggested that nocebo mechanisms might, in part, explain health responses to equipment emitting EMF (Danker-Hopfe et al., 2010; Foster and Rubin, 2014; Rubin et al., 2010; Schreier et al., 2006).

Few studies have investigated health responses to equipment emitting EMF and its relationship to nocebo mechanisms outside of the laboratory. Some cross-sectional studies have shown that indicators of perceived exposure to a power line or mobile phone base station (i.e. visibility, actual proximity, perceived proximity), were associated with beliefs about negative health effects of exposure to EMF (Blettner et al., 2009; Kowall et al., 2012; Poortinga et al., 2008; Preece et al., 2007). This illustrates the potential for nocebo responses to occur in people living in the vicinity of this type of equipment. The limited evidence for increased symptom reporting in line with these beliefs is mixed. Where Preece et al. (2007) found that proximity to military antennae emitting electromagnetic fields was related to beliefs about the health effects as well as to symptom reports, McMahan and Meyer (1995) did not find a relationship either between proximity to a power line and reported symptoms, or between proximity and beliefs about health effects of electromagnetic fields. To our knowledge, no field studies have tested explicitly whether an increase in reported symptoms was mediated by beliefs regarding adverse health effects of exposure.

The increasing demands for reliable and renewable energy supplies have led to the construction of new HVPLs all over the world (Kheifets et al., 2010; Vajjhala and Fischbeck, 2007). The introduction of new HVPLs in the Netherlands provides the unique opportunity to study health responses to a potential environmental risk in a prospective manner (see Porsius et al., 2014). In previous work we found that after a new HVPL was put into operation, residents living close by reported more cognitive and somatic symptoms in comparison to a control group of residents living farther away (Porsius et al., 2015b). In addition, nearby residents showed a parallel increase in the belief that a power line had caused these symptoms, as well as stronger beliefs before the line was put into operation. In the present study, we investigate whether the increase in reported symptoms we previously found, can be explained by beliefs regarding the health effects of power lines by applying longitudinal mediation models (see MacKinnon, 2008). Such a finding would support the role of nocebo mechanisms in health responses after the introduction of an electrical source emitting EMF.

2. Material and methods

2.1. Participants and procedure

Participants were residents living in the vicinity of a newly introduced high-voltage power line route in the Netherlands (for a full description see Porsius et al., 2014). All residents living close by (0–300 m and 300–500 m) received an invitation to participate in a longitudinal environmental health study, as well as a control group of residents living farther away (500–2000 m). All available addresses within 500–2000 m were stratified for area (West vs. East), distance (500–1000 m, 1000–1500 m, 1500–2000 m) and degree of urbanization (less than 1000 and 1000–2500 addresses per km^2). We drew random samples (using SPSS random number generator) from these strata matching the proportion of addresses in rural and urban areas of the households within 500 m of the new power line route. To reduce the potential for response bias and demand characteristics power lines were not mentioned in the invitation letter. Participants filled out questionnaires digitally (or on request on paper) during construction of the new line before it was put into operation (T1, T2) and approximately 2 (T3) and 7 months (T4) after it was put into operation. At T1 major construction work was carried out, while at T2 the power line route was visibly finished but not yet operational. The moment that the line would be put into operation was communicated by the electricity grid operator through postal mail and over the internet. Questions about health preceded questions about the environment, and questions regarding power lines were embedded in a list of other environmental factors.

Residents who did not respond to our invitation at T1, were invited again to participate at T2. In total, 1254 residents participated in our study (0–300 m, n = 229, 300–500 m, n = 489, 500–2000 m, n = 536), with response rates at T1 and T2 varying from 16.2% to 26.6% depending on the distance group (higher for residents living closer to the new line). 40.7% of the respondents participated at all four measurement waves, 23.2% at three, 17.3% at two and 18.8% at one. Attrition was not significantly different between the distance groups and did not depend on the outcome measures in our study. Participants were on average 52 years old (SD = 13) and 46% were male. The majority of the participants have had higher education (43.8%), 33.8% middle and 22% lower. Participants living closer to the new line were on average of higher socio-economic status than residents living farther away (see Porsius et al., 2015b for a full description of the sample).

2.2. Materials

2.2.1. Cognitive and somatic symptom reports

The experience of cognitive problems was assessed with a Dutch translation of the MOS Cognitive Functioning Scale (Stewart et al., 1992). The scale consists of 6 items tapping the domain of general cognitive functioning (e.g. forgetfulness, difficulty concentrating, trouble maintaining attention). On a 6-point scale (ranging from all of the time, through to none of the time), participants indicated how often they experienced a specific cognitive problem during the previous week. Scores were recoded and an average score was calculated, resulting in a score between 1 and 6.

The experience of somatic symptoms was assessed with the somatization scale of the Dutch 4DSQ (Terluin et al., 2006). The scale consists of 16 non-specific somatic symptoms commonly reported in GP practices such as headaches, dizziness and low back pain. For each health complaint, participants indicated whether they were bothered by it during the previous week on a 5-point scale (ranging from no, through to constantly). Following instructions (see Terluin et al., 2004), scores were trichotomized and summed resulting in a minimum score of 0 and a maximum score of 32. For both cognitive and somatic health complaints, higher scores indicate more reported symptoms.

2.2.2. Beliefs about health effects of power lines

Beliefs about the health effects of power lines were measured by asking about causes of experienced health complaints (causal belief) and expectations to develop health complaints (negative expectations). To assess causal beliefs we asked participants to indicate on a 5-point scale (from 1 = certainly not, to 5 = certainly and 6 = not applicable) whether they believed that their health complaints during the previous week were caused or worsened by an overhead power line (amongst 10 other environmental factors; e.g. wind turbines, busy roads and mobile phone base stations). All scores of participants who did not report any health complaints were recoded to a missing value. For participants who did report health complaints the not applicable score was recoded to 1 (certainly not). Negative health expectations of living near a power line were assessed by asking participants to indicate on a 5-point scale (from 1 = certainly not, to 5 = certainly) whether they think they would get health complaints if they lived near an overhead power line (amongst the 10 other environmental factors). For both causal beliefs and negative health expectations, higher scores indicate stronger beliefs about the adverse health effects of power lines.

2.3. Statistical analyses

In a previous paper we reported a larger increase in symptom reports after a new power line was put into operation in residents living nearby (0–300 m) compared to farther away (500–2000 m) (Porsius et al., 2015b). In the present follow-up study we used structural equation modeling (SEM) to investigate whether this longitudinal difference was mediated by beliefs regarding the health effects of power lines (i.e. causal beliefs and negative expectations). Within SEM, longitudinal mediation can be tested with latent growth curve modeling (Cheong et al., 2003; von Soest and Hagtvet, 2011). In latent growth curve models, longitudinal data are modeled by a latent intercept and slope, representing the initial status of a person on an outcome and the individual change over time respectively. In non-randomized studies mediation can occur both through the intercept and the slope (see von Soest and Hagtvet, 2011). In our study, mediation through the intercept would mean that proximity to the new power line affects the increase in reported symptoms indirectly through the mediator as measured *before* the power line was put into operation. Mediation through the slope would mean that the *change* in the mediator *after* the power line was put into operation is indirectly causing the increase in reported symptoms. We tested both these hypothesized effects simultaneously in multiple mediation models following the von Soest and Hagtvet (2011) specification. In these models we specified the slopes as T1 (0), T2 (0), T3 (1), and T4 (1), representing the change after the new line was put into operation. As a consequence the intercepts represent the initial status before the line was put into operation (i.e., T1 and T2).

To assess whether and to what extent mediation occurred, we calculated the product of the *a* paths (see Fig. 1 *a*1: proximity → intercept mediator; *a*2: proximity → slope mediator) with the respective *b* paths (see Fig. 1 *b*1: intercept mediator → slope outcome; *b*2: slope mediator → slope outcome). In line with previous work proximity was dummy coded (0–300 m and 300–500 m) with residents living farther away (500–2000 m) as reference group. Because the increase in symptoms occurred in the 0–300 m group (Porsius et al., 2015b), indirect effects were calculated for this group. Therefore the product of the *a* and *b* paths can be interpreted as the estimated amount of increase in reported symptoms in the 0–300 m group (relative to the 500–2000 m group) which is indirectly explained by the mediator. The ratio of the indirect to the total effect of proximity is calculated as an effect size measure (P_M, see MacKinnon, 2008; Wen and Fan, 2015). In our study this ratio indicates how much of the effect of proximity on the increase in reported symptoms is explained by the indirect effect through the mediator (ranging from 0 to 1). Whether significant mediation occurred was determined by calculating 95% bias-corrected confidence intervals based on 5000 bootstrap samples for the estimates of the indirect effects (see MacKinnon et al., 2004). Significance of the other estimates in the models was also based on unstandardized bias-corrected confidence intervals.

Models were estimated separately for cognitive and somatic symptoms, and for the two potential mediators; causal beliefs and negative health expectations. Full information maximum likelihood estimation was used for all models. To assess the overall absolute fit we present

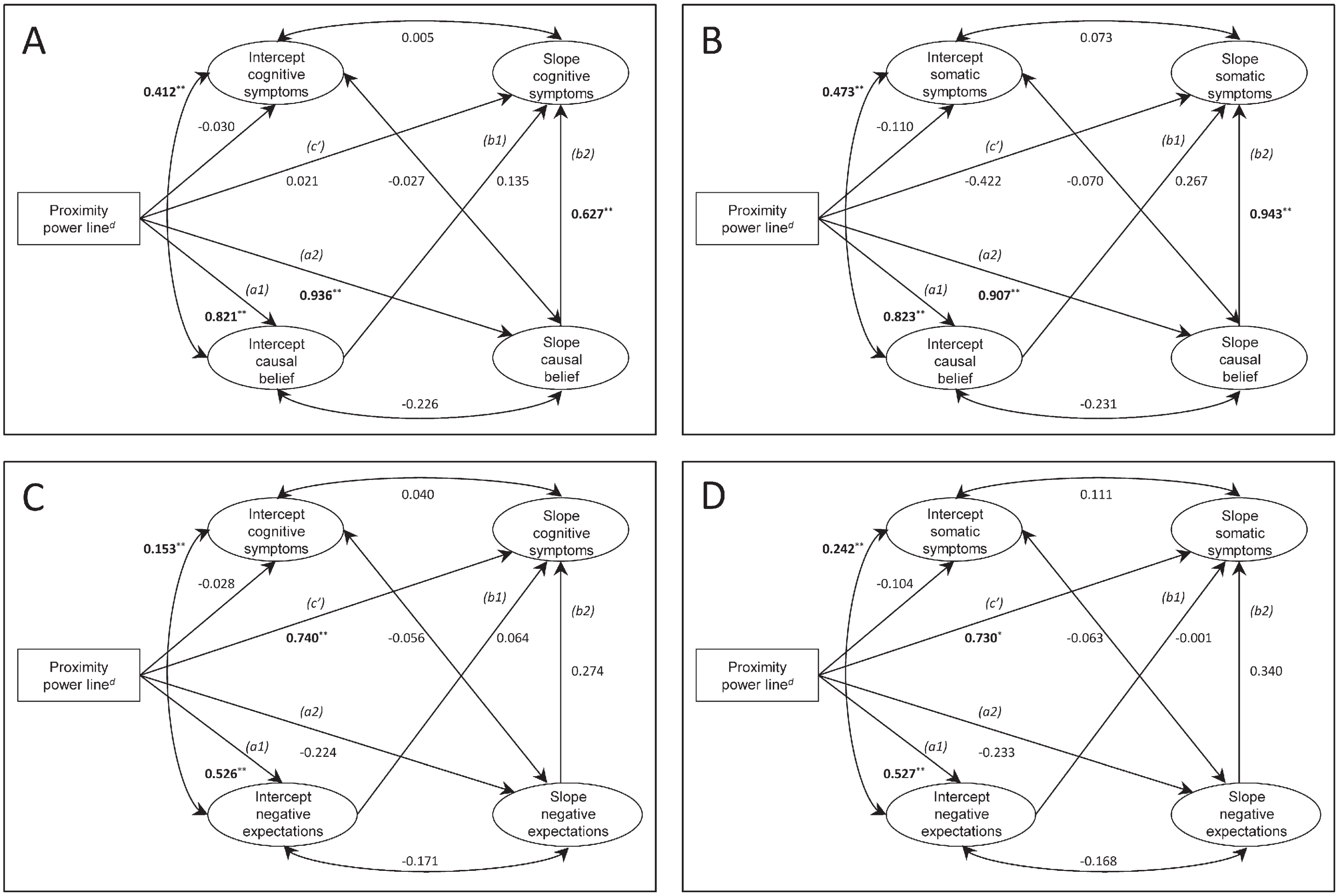

Fig. 1. Longitudinal mediation models for an increase in reported cognitive and somatic symptoms as mediated by causal beliefs (panels A and B) and negative health expectations (panels C and D) with standardized estimates. ($a1$) and ($b1$) paths refer to hypothesized indirect effects of proximity on an increase in reported symptoms through the initial status of the mediator before the power line was put into operation. ($a2$) and ($b2$) paths refer to hypothesized indirect effects of proximity on an increase in reported symptoms through a change in the mediator after the power line was put into operation. (c') path refers to the direct effect of proximity on an increase in reported symptoms adjusted for the mediators. *Bias-corrected bootstrapped 95% confidence interval does not contain 0. **Bias-corrected bootstrapped 99% confidence interval does not contain 0. [d]Estimates refer to residents living close by (0–300 m) compared to farther away (500–2000 m).

the RMSEA and CFI values. For RMSEA, models with values ≤ 0.06 have acceptable fit and for CFI values ≥ 0.95 have acceptable fit (Hu and Bentler, 1999). To compare the non-nested models we also present the Akaike Information Criterion (AIC) and the Bayesian Information Criterion (BIC). For both these indices lower values indicate a better fit. All analyses were performed in Mplus version 6.12.

3. Results

3.1. Increase in symptoms mediated by strength of causal belief

Fig. 1 shows the longitudinal mediation models for cognitive (panel A) and somatic symptom reports (panel B) as mediated by the strength

Table 1
Beta estimates of the indirect, direct and total effects of proximity on growth in cognitive and somatic symptom reports with model fit indices.

	Beta estimates (95% CI[a])			
	Cognitive symptom reports		Somatic symptom reports	
	Mediator		Mediator	
	Causal belief model	Negative expectations model	Causal belief model	Negative expectations model
Effects of proximity				
Indirect via intercept	0.027 (−0.043, 0.110)	0.008 (−0.020, 0.039)	0.186 (−0.224, 0.628)	0.000 (−0.150, 0.132)
Indirect via slope	0.144** (0.039, 0.844)	−0.015 (−0.209, 0.012)	0.724** (0.194–4.057)	−0.067 (−1.094, 0.066)
Direct	0.005 (−0.525, 0.183)	0.184** (0.065, 0.332)	−0.358 (−3.243, 0.488)	0.615* (0.027, 1.295)
Total	0.177** (0.070, 0.291)	0.177** (0.069, 0.289)	0.553* (0.081, 1.046)	0.547* (0.070, 1.036)
Model fit				
RMSEA	0.028	0.018	0.023	0.014
CFI	0.990	0.995	0.995	0.998
AIC	14,990.264	17,206.641	27,032.493	29,279.050
BIC	15,143.926	17,360.302	27,186.155	29,432.712

[a] Bias-corrected bootstrapped confidence intervals with 5000 samples.
* Bias-corrected bootstrapped 95% confidence interval does not contain 0.
** Bias-corrected bootstrapped 99% confidence interval does not contain 0.

of the belief that reported symptoms were caused by an overhead power line. All models provided a good fit to the data (see fit indices, Table 1). Standardized coefficients are reported to enhance interpretation of the strength of the relationships in Fig. 1. In line with previous work (Porsius et al., 2015b), we found a significant association between proximity to the new line and the strength of the belief that reported symptoms were caused by a power line before the new line was put into operation (Fig. 1A and B, *a*1 path), as well as an increase after the new line was put into operation (Fig. 1A, and B, *a*2 path). Only the latter increase in causal beliefs was significantly associated with reporting more cognitive and somatic symptoms after the line was put into operation (Fig. 1A and B, *b*2 paths). The standardized coefficient of the *b*2 path was larger for somatic symptom reports indicating a stronger effect of a change in causal beliefs on a change in somatic symptom reports when compared to cognitive symptoms. In addition, the full model explained more variance in the change in somatic symptom reports than in cognitive symptom reports (R^2 somatic slope: 0.79; R^2 cognitive slope: 0.41).

Table 1 displays the bias-corrected confidence intervals for the indirect, direct and total effects of proximity to the new line. For both cognitive and somatic symptom reports the confidence intervals for mediation through the intercept of causal beliefs did not indicate significant mediation. In contrast, mediation through the slope of causal beliefs was significant. Residents living close by (0–300 m) were estimated to have a larger increase of 0.144 in self-reported cognitive symptoms (on a 6-point scale, average score before the line was put into operation $M = 1.74$, $SD = 0.75$) indirectly through mediation of an increase in causal beliefs, when compared to residents living farther away (500–2000 m). Relative to the total effect of proximity (0.177), this gives an effect size of $P_M = 0.81$. For somatic symptom reports the indirect effect was estimated to be 0.724 (on a 32-point scale, average score before the line was put into operation, $M = 4.19$, $SD = 4.00$). The effect of proximity on somatic symptoms, adjusted for the strength of causal belief, was negative (i.e. estimate of the direct effect). This suggests inconsistent mediation (see MacKinnon, 2008), although the direct effect did not reach significance. When a direct effect is negative, the relative ratio of the indirect effect to the total effect cannot be interpreted (Wen and Fan, 2015). No significant effects were found for mediation through the intercept of causal beliefs.

3.2. Increase in symptoms mediated by negative expectations

Fig. 1 displays the longitudinal mediation models with negative health expectations of living near a power line as potential mediator (panels C and D). For these models an excellent fit was found as well, but inspection of the comparative indices (AIC, BIC) suggests a worse overall fit when compared to the causal belief models (Table 1). We found a significant *a* path (Fig. 1C and D, path *a*1) from proximity to negative expectations before the power line was put into operation, but proximity was not associated with an increase in expectations after the line was put into operation (Fig. 1C and D, path *a*2). Neither the intercept nor the slope of negative expectations was significantly associated with the cognitive and somatic symptom slopes. Only the association between negative expectations and symptom reporting before the line was put into operation was significant, and larger for reporting somatic symptoms. The absence of a significant *b* path (Fig. 1C and D, *b*1 and *b*2), and a significant c' path, suggests no mediation which was confirmed when the indirect effects were calculated (Table 1). The explained variance of the cognitive and somatic slopes was comparable (R^2 somatic slope: 0.18; R^2 cognitive slope: 0.16), but considerably lower than in the causal belief models.

4. Discussion

In previous work we found a negative impact of a new HVPL on cognitive and somatic symptoms reports (Porsius et al., 2015b). The present study extends those findings by demonstrating that this increase can be explained through beliefs about the health effects of power lines. Mediation occurred through the increase in the strength of causal belief after the power line was put into operation, to such an extent that proximity did not explain any additional variance in the increase in reported cognitive and somatic symptoms. These findings support the role of nocebo mechanisms in symptom reporting after the introduction of a new HVPL.

Previous cross-sectional studies showed a relationship between causal beliefs involving environmental exposures and the intensity of experienced symptoms (Bailer et al., 2007; Baliatsas et al., 2014; van Dongen et al., 2014). Interviews with IEI-EMF patients indicate that their attribution of symptoms to EMF began with a period of suffering from non-specific health complaints (de Graaff and Broer, 2012) and case reports suggest that symptoms became worse when the conviction of EMF as a cause of these complaints became stronger (Bergqvist and Vogel, 1997). Our findings in a general population sample suggest a reciprocal relationship. An increase in experiencing distressing somatic or cognitive symptoms after a suspected environmental exposure went hand in hand with an increase in the strength of the belief that symptoms are caused by the exposure. Although these causal beliefs were already stronger in residents living nearby before the power line was put into operation and before symptoms increased, we did not find support for these stronger beliefs at baseline to be related to the subsequent increase in reported symptoms.

Our study is one of the few studies investigating the psychological mechanisms through which a change in the environment may affect health perceptions of affected residents. Other studies focus more on the role of personality related variables in reporting symptoms related to the environment. Previous research has for instance suggested negative oriented personality traits (Taylor et al., 2013), high levels of stress (Eek et al., 2010), negative affect (Skovbjerg et al., 2015) and concern about environmental exposures (Petrie et al., 2005) as risk factors for reporting health complaints related to the environment. Our study adds to this body of research that a potential environmental risk event (i.e. putting a new HVPL into operation) can change beliefs of residents about the health effects of exposure, which concurrently affects the way people perceive their health.

Our pattern of findings, in which the *increase* in symptoms was only explained by an *increase* in causal beliefs, suggests that somatosensory amplifying processes were triggered by putting the new power line into operation. Somatosensory amplification is the mechanism in which somatic sensations get amplified, and are experienced as health complaints due to cognitive and affective factors (Barsky, 1992; Barsky and Wyshak, 1990). It is likely that symptoms become intensified if one believes that they are caused by a serious factor that cannot be easily changed, like living close to an HVPL. The resulting stronger symptom experience may have further strengthened the belief that these symptoms were caused by the new power line, illustrating the reciprocal character of this relationship between beliefs and symptoms.

We did not find support for negative health expectations of a power line as mediator of an increase in reported symptoms. Negative health expectations regarding power lines were assessed in a general fashion without reference to a time frame, which was different from causal beliefs. Therefore these negative expectations might tap more into a trait-like dimension which is supported by our finding that negative expectations did not change after the line was put into operation. As such, it could reflect a stable perceived susceptibility to health effects of power lines and be a more likely moderator instead of mediator. Another potential measurement issue is related to the difficulty of validly measuring expectations. When asking someone about his or her expectations regarding an exposure, one might be more directed to form a high-level abstract construal of the exposure than a low-level concrete one due to the hypothetical phrasing of the question (see Trope and Liberman, 2003). These aspects might explain why negative expectations did not contribute to explaining the change in reported symptoms.

There are limitations to the interpretation of our findings. Although longitudinal mediation provides a more convincing case for temporal precedence than cross-sectional studies (Lockhart et al., 2011), it does not warrant us from the usual limitations of observational studies with regard to internal validity. Based on the nocebo hypothesis we modeled beliefs about the health effects of power lines as mediator and symptom reports as outcome. However, our method cannot exclude a reverse pattern with symptom reports as mediator of beliefs about health effects. Somatosensory amplification might have started with an increase in reported symptoms due to other unmeasured potential mediators that might have played a role. For instance, the role of actual exposure to extremely low frequency electromagnetic fields from the new power line. Second, although observational studies suffer less from demand characteristics than laboratory studies, we cannot exclude the possibility that the effects we found were in part the result of our own research. Like in any survey, asking people about their beliefs and feelings can inadvertently influence those beliefs and feelings. In our control group we did not see indications of such effects. Beliefs regarding power lines remained stable over the course of our study. However, for the residents living close to the new power line our questions might have had an unintended adverse effect, offering an additional explanation for the increase in causal beliefs and symptoms we found.

Our findings indicate that putting a power line into operation can lead to symptomatic experiences through beliefs about the health risks. Future prospective research is needed to know whether our findings extend to other environmental health issues in a community, such as the construction of a new mobile phone base station or wind turbine. Our findings also raise questions about how beliefs about the health effects of environmental exposures are formed. Why did residents living closer to the new power line had stronger negative beliefs regarding the health effects? An explanation might be found in the role of communication when a new power line is being introduced.

The experience of risk is for a large part determined by communication about a potential risk event through formal (e.g. news media and official authorities) and informal (e.g. friends, neighbors, and social groups in general) networks (Kasperson et al., 1988). Recent studies illustrate that nearby residents do not feel involved in the planning process of new power lines and distrust the authorities regarding provided information about the health risks (Cotton and Devine-Wright, 2013; Keir et al., 2014). Instead, residents appear to rely more on messages in the media (Porsius et al., 2015a) which have been shown to portray the health effects of exposure to EMF as more negative than warranted by scientific evidence (Claassen et al., 2012; Eldridge-Thomas and Rubin, 2013). In addition, it appears that other burdens associated with living near a power line (e.g. visual intrusion and decreased property values) interact closely with the perceived health risks of EMF (Elliott and Wadley, 2012). Future studies should further investigate the role of risk communication in beliefs about the health effects of environmental exposures. This could provide focal points to reduce nocebo responses when uncertain environmental health risks are introduced into the environment.

Competing interests

The authors declare they have no actual or potential competing financial interests.

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